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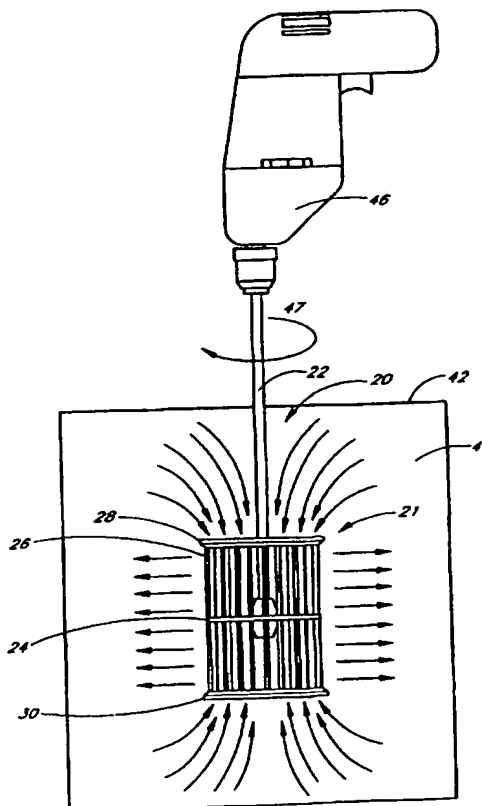
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: <b>PCT/US96/19345</b> (22) International Filing Date: <b>5 December 1996 (05.12.96)</b> (30) Priority Data: <b>08/567,271</b> <b>5 December 1995 (05.12.95)</b> <b>US</b> (60) Parent Application or Grant (63) Related by Continuation <b>US</b> <b>08/567,271 (CIP)</b> <b>Filed on</b> <b>5 December 1995 (05.12.95)</b> (71)(72) Applicants and Inventors: <b>KING, David, Marshall</b> <b>[US/US]; 1044 W. Hartley, Ridgecrest, CA 93555 (US).</b> <b>KING, Ronald, Brian [US/US]; 140 Mojave Rose,</b> <b>Ridgecrest, CA 93555 (US). MARTIN, Thomas, Arnold</b> <b>[US/US]; 228 E. Hartley, Ridgecrest, CA 93555 (US).</b> (74) Agent: <b>ALTMAN, Daniel, E.; Knobbe, Martens, Olson and</b> <b>Bear, 16th floor, 620 Newport Center Drive, Newport Beach,</b> <b>CA 92660 (US).</b>		(81) Designated States: <b>AL, AM, AT, AU, AZ, BA, BB, BG, BR,</b> <b>BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE,</b> <b>HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS,</b> <b>LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL,</b> <b>PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA,</b> <b>UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ,</b> <b>UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ,</b> <b>TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR,</b> <b>GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF,</b> <b>BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b>  <b>Published</b> <i>With international search report.</i>

(54) Title: **METHOD OF MIXING VISCOUS FLUIDS**

(57) Abstract

A method of mixing viscous fluids is disclosed. The method comprises rotating a mixing apparatus (20) in a container (42) of fluid (44). The mixing apparatus comprises a cage (21) located at the end of a shaft (22). The cage (21) comprises a central circular disc (24) with an outer edge (43) and top (38) and bottom (40) sides. A number of vanes (26) extend from each side of the disc (24), the vanes (26) spacedly located near the outer edge of the plate. The free ends of the vanes (26) are connected by a hoop (38, 40) to maintain their spaced relationship.



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**METHOD OF MIXING VISCOUS FLUIDS**Field of the Invention

The present invention relates to a method of mixing fluids. More particularly, the present invention is a method of mixing viscous fluids by rotating a multi-vaned mixer.

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Background of the Invention

The mixing of viscous fluids has historically been a difficult task. Present methods of mixing such fluids often result in inadequate mixing and are time-consuming and energy consumptive.

One of the more common viscous fluids which must be mixed is paint. Homeowners and painters are all too familiar with the task of mixing paint.

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Probably the most common method of mixing fluid such as paint involves the user opening the container, inserting a stir stick or rod and rotating or moving the stick about the container. This method is tiring, requiring tremendous effort to move the stir stick through the viscous fluid. Because of this, individuals often give up and stop mixing long before the paint is adequately mixed. Further, even if the individual moves the stir stick for a long period of time, there is no guarantee that the paint is thoroughly mixed, rather than simply moved about the container.

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Many mechanisms have been proposed for mixing these fluids and reducing the manual labor associated with the same. These mechanisms have all suffered from at least one of several drawbacks: users have difficulty in using the device because of its complexity or size, the device inadequately mixes the fluid, the device mixes too slowly, the device does not break up or "disperse" clumped semi-solids in the fluid, and/or the user has a difficult time cleaning up the device after using it. Other problems associated with these mixers are that they often introduce air into the fluid (which, in the case of paint is detrimental, for example, when the paint is to be sprayed with a sprayer), and some of the mixing devices may damage the container in which the fluid is being mixed, causing the fluid to leak from the container.

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One example of such a mechanized mixing device is essentially a "screw" or auger type device. An example of such a device is illustrated in U.S. Patent No. 4,538,922 to Johnson. This device is not particularly effective in mixing such fluids, as it imparts little velocity to the fluid. Further, the device does not disperse clumped fluid material, but simply pushes it around the container.

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Another method for mixing paint comprises shaking the paint in a closed container. This can be done by hand, or by expensive motor-driven shakers. In either instance, the mixing is time consuming and often not complete. Because the shaking occurs with the container closed, little air space is often available for the fluid therein to move about. Therefore, the shaking often tends to move the fluid very little within the container.

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Several devices have been developed for mixing paint which comprise devices for connection to drills. For example, U.S. Patent No. 4,893,941 to Wayte discloses a mixing device which comprises a circular disc having vanes connected thereto. The apparatus is rotated by connecting a drill to a shaft which is connected to the disc. This device suffers from several drawbacks. First, the limited number of vanes does not provide for thorough mixing. Second, because the bottom disc is solid, no fluid is drawn through the device from the bottom. It is often critical

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that fluid from the bottom of the container be drawn upwardly when mixing viscous fluids, since this is where the heaviest of the fluids separate prior to mixing.

U.S. Patent No. 3,733,645 to Sailer discloses a paint mixing and roller mounting apparatus comprising a star-shaped attachment. This apparatus is not effective in mixing paint, as it does not draw the fluid from the top and bottom of the container. Instead, the paddle-like construction of the device simply causes the fluid to be circulated around the device.

U.S. Patent No. 1,765,386 to Wait discloses yet another device for mixing liquids. This device is wholly unacceptable, as it must be used in conjunction with a diverter plate located in the container to achieve adequate mixing. Use of the diverter plate would either require its installation into a paint container before being filled, which would increase the cost of paint to the consumer, or require that the consumer somehow install the device into a full paint container.

An inexpensive method for mixing viscous fluids in a quick and effective manner is needed.

#### Summary of the Invention

The present invention is a method of mixing viscous fluids. The method comprises locating a mixing device in a container of fluid and rotating said device in said fluid with rotary drive means. The mixing device preferably comprises a mixing cage connected to a shaft.

The shaft is elongate, having a first end connected to a central plate and a second free end for connection to the rotary drive means. The plate is solid, circular, and has a top side, bottom side, and outer edge.

Vanes in the form of thin, curved slats, are spacedly positioned about the outer edge of each side of the plate. The vanes extend outwardly from each side of the plate parallel to the shaft. A first end of each vane is connected to the plate near the outer edge thereof. The vanes are connected at their second ends by a hoop.

The vanes preferably have a length which is between about .1 - 2 times the diameter of the plate. The number of vanes located about each side of the plate preferably number between 4 and 12 per inch diameter of the plate. Each vane preferably extends inwardly from the periphery of the plate no more than about .1 - .35 of the distance from the center of the plate to the periphery thereof at that location.

In use, a user positions the mixing cage of the device in a container of fluid. The user connects the free end of the shaft to the rotary drive means, such as a drill, and rotates the cage within the fluid.

The device has been found to be extremely effective in mixing viscous fluids such as paint. The device draws fluid, without the need of a diverter plate, from the top and bottom of the container. This fluid is dispersed at high velocity radially outwardly through the vanes.

The device is easy to use, as a user need only connect it to a drill. The device is easy to clean, the user needing only to relocate it and rotate it in a container of cleaning fluid.

Further objects, features, and advantages of the present invention over the prior art will become apparent from the detailed description of the drawings which follows, when considered with the attached figures.

Brief Description of the Drawings

FIGURE 1 is a perspective view of a mixing device for use in the method of the present invention;

FIGURE 2 is a top view of the mixing device of Figure 1;

FIGURE 3 is a side view of the mixing device of Figure 1;

5 FIGURE 4 is a bottom view of the mixing device of Figure 1; and

FIGURE 5 illustrates use of the mixing device of Figure 1 to mix a fluid in a container.

Detailed Description of the Preferred Embodiment

10 The present invention comprises a method of thoroughly mixing a fluid with a mixing device. In general, the method comprises rotating the mixing device in a container containing the fluid. As used herein, the term "fluid" is intended to mean liquids, especially those of a viscous nature whether containing dissolved or undissolved solids, slurries, gels and those groupings of solid or semi-solid materials which behave in some respects as a fluid, such as granular materials (e.g. flour, sugar, sand etc.).

As illustrated in Figure 1, the mixing device 20 generally comprises a cage-like structure having open ends. As illustrated in Figure 5, the device 20 includes a shaft 22 for rotation by rotary drive means such as a drill 46, 15 the shaft connected to a central connecting plate 24. Vanes 26 extend outwardly from each side of the central connecting plate 24 parallel to the shaft 22. The vanes 26 are connected at their ends opposite the plate by a hoop 28,30.

20 In use, a user positions the mixing device in a container 42 of fluid 44. The user connects the shaft 22 of the device 20 to a drill 46 and rotates it within the fluid. As illustrated in Figure 5, the mixing device 20 mixes the fluid by drawing it from the top and bottom of the container 42 and forcing it radially outward through the vanes 26.

The mixing device 20 for use in the present invention will now be described with more particularity with reference to Figures 1-5. In general, and as illustrated in Figure 1, the device 20 includes mixing cage 21 connected to a shaft 22, the mixing cage 21 comprising a central connecting plate 24, vanas 26, and two hoops 28,30.

25 The shaft 22 is an elongate rigid member having a first end 32 and second end 34. The exact length and diameter of the shaft 22 depends on the depth of the fluid in the container to be mixed. When the device 20 is for use in mixing paint in a standard one-gallon paint can, the shaft 22 can be about 8 - 9 inches long and about .25 inches in diameter.

30 The first end 32 of the shaft 22 is adapted for connection to a rotary drive means. Preferably, the rotary drive means comprises a drill, as illustrated in Figure 5. Preferably, the shaft diameter is chosen so that engagement with the rotary drive means is facilitated.

The second end 34 of the shaft 22 is connected to said central plate 24. Preferably, the second end 34 of the shaft 22 engages an adapter 36 connected to the plate 24. The shaft end 34 engages the plate 24 at the center point of the plate 24.

35 The central plate 24 comprises a flat, disc-shaped member having a top surface 38, bottom surface 40 and outer edge 43. The shaft 22 engages the plate 24 at the top surface 38 thereof.

Preferably, the plate 24 is constructed of durable and fairly rigid material. The plate 24 may be any of a variety of sizes. When used for batch mixing of quantities of one gallon of highly viscous (i.e. resists flow) liquids such as paint, it is preferably about 1 - 4, and most preferably about 2.5 inches in diameter.

5 A number of vanes 26 extend from the top and bottom surface 38,40 respectively, of the plate 24 near the outer edge 43 or periphery thereof. Each vane 26 has a first edge and a second edge, being curved therebetween. The curved shape of the vane 26 causes the vane to have a concave surface 27 and a convex surface 28 (see Figures 2 and 4). All of the vanes 26 are oriented on the plate 24 in the same direction. The vanes 26 are oriented on the plate 24 in a manner such that they face in the direction of rotation indicated by arrow 47 in Figures 1, 2, 4 and 5, when rotated by the rotational drive means 46.

10 The vanes 26 are preferably constructed of durable and fairly rigid material. It has been found preferable that the ratio of the length of the vanes 26 to the diameter of the plate be between about .1 and 2, and most preferably between .2 and .7. Moreover, it has been found preferable that the number of vanes 26 be dependent on the ratio of the diameter of the plate 24 on the order of about 4-12, and most preferably about 9 vanes per inch diameter of the plate 24. The width of each vane 26 is preferably no more than .1 to .35 times the radius of the plate 24, and more preferably about .1 - .3, and most preferably about .25 times the radius of the plate 24. The thickness of each vane 26 depends on the material from which it is made. Regardless of its width, each vane 26 is preferably positioned at the outer edge 43 of the plate 24 such that the vane 26 extends inwardly therefrom no more than about .1- .35, more preferably less than about .3, and most preferably less than about .25, of the distance from the center of the plate 24 to the periphery thereof at that vane 26 location (i.e. less than about .35 the radius when the plate 24 is circular).

20 Where the device 20 is configured for use in mixing paint in a one-gallon container and the plate 24 diameter is about 2.5 inches, the vanes 26 are preferably about 1 inch long from their ends at the connection to the plate 24 to their ends connected at the hoops 28,30. Each vane 26 is preferably about .2 - 1, and most preferably about .3 inches wide.

25 In order to disperse partially solidified particulate in the fluid, the vanes 26 are fairly closely spaced about the outer edge 43 of the plate 24. The vanes 26 are preferably spaced about .1 - 1 inch, and most preferably about .25 inches apart. When the vanes 26 are spaced far apart (e.g. about 1 inch) the vane width and/or height is preferably increased within the above-stated range or ratios. Thus, in the case where the plate 24 has a diameter of about 2.5 inches, there are preferably about twenty-four vanes 26, as illustrated in Figures 1, 2 and 4.

30 In order to prevent relative movement between the free ends of the vane 26, this end of each vane is connected to a support hoop 28,30. The hoop 28,30 comprises a relatively rigid circular member of "L"-shape cross-section. A first portion of each hoop 28,30 extends over the end of each of the vanes, and a second portion of each hoop 28,30 extends downwardly along the outer surface of each vane, as illustrated in Figures 2-4. Each vane 26 is securely connected to its corresponding hoop 28,30.

35 Use of the device 20 described above in the method of the present invention will now be described with reference to Figure 5.

A user obtains a container 42 containing fluid 44 to be mixed. This container 42 may comprise a paint can or any other container. The fluid 44 to be mixed may comprise nearly any type of fluid, but the method of the present invention is particularly useful in mixing viscous fluids.

5 The user attaches the device 20 of the present invention to rotary drive means. As illustrated in Figure 5, the preferred means comprises a drill 46. The means may comprise other apparatus other than a drill, however, such as pulley or gas motor driven means. These drive means preferably turn the shaft 22 of the device at speed dependent upon the viscosity of the fluid. For example, for low viscosity fluids, the rotational speed may be often as low as about 500 rpm, while for high viscosity fluids the rotational speed may often be as high as 1,500 rpm or more. The user attaches the first end 32 of the shaft 22 to the drill 46, such as by locating the end 32 of the  
10 shaft in the chuck of the drill.

Once connected, the user lowers the mixing cage 21 into the fluid 44 in the container 42. The user locates the mixing cage 21 below the top surface of the fluid.

Once inserted into the fluid 44, the drill 46 is turned on, thus effectuating rotational movement of the mixing cage 21. While the cage 21 is turning, the user may raise and lower it with respect to the top surface of  
15 the fluid and the bottom of the container, as well as move it from the center to about the outer edges of the container, so as to accelerate the mixing of the fluid therein.

Advantageously, and as illustrated in Figure 5, the device 20 of the present invention efficiently moves and mixes all of the fluid 44 in the container 42. In particular, because of the location of vanes extending from and separated by the central plate 24, the mixing cage 21 has the effect of drawing fluid downwardly from above the  
20 location of the cage 21, and upwardly from below the cage, and then discharging the fluid radially outwardly (as illustrated by the arrows in Figure 5). This mixing effect is accomplished without the need for a diverter plate in the bottom of the container.

Most importantly, partially solid particulate in the fluid is effectively strained or dispersed by the vanes 26 of the cage 21. The close spacing of the vanes 26 traps unacceptably large undeformable globules of fluid or other  
25 solid or partially solid material in the cage, for removal from the cage after mixing. Other globules of partially solidified fluid material are sheared apart and dispersed when they hit the vanes, reducing their size and integrating them with the remaining fluid.

Advantageously, optimum mixing is achieved with the present device 20 as a result of the positioning of substantially long inner and outer vane edges at the periphery of the plate 24. This allows the fluid moving through  
30 the device 20 to impact upon the inner edge of the vane 26 at a high radial velocity and therefore with great force. Further, the outer edge of the vane has a high velocity in relation to the fluid in the container positioned outside of the device 20, thereby impacting upon that fluid with great force.

The ratio of the length of each vane to its width, and their placement at the periphery of the plate, creates maximum fluid flow through the cage 21. This is important, for it reduces the total time necessary to mix the fluid  
35 in a particular session.

Notably, the hoops, 28, 30 protect the container from damage by the spinning vanes 26. This allows the user to be less careful in positioning the cage 21 in the container 42, as even if the cage 21 encounters the sides or bottom of the container, the cage is unlikely to damage the container.

5 Another advantage of the mixing device 20 of the present invention is that it mixes the fluid without introducing air into the fluid, as is a common problem associated with other mixers utilized for the same purpose. As can be understood, the introduction of air into a fluid such as paint is extremely detrimental. For example, air within paint will prevent proper operation of many types of paint sprayers and makes uniform coverage when painting difficult. The presence of air is also detrimental, for example, where a polyurethane coating being applied, as air bubbles become trapped in the coating and ruin its appearance.

10 After the fluid has been adequately mixed, cleaning of the device 20 is fast and easy. A user prepares a container filled with a cleaning agent. For example, in the case of latex paints, water is an effective cleaning agent. The user lowers the cage 21 into the cleaning agent, and turns on the drill 46. The rapid movement of the cleaning agent through the cage 21 causes any remaining original fluid (such as paint) thereon to be cleansed from the device 20.

15 Once the device 20 is clean, which normally only takes seconds, the device can be left to air dry.

The dimensions of the device 20 described above are preferred when the device is used to mix fluid in a container designed to hold approximately 1 gallon of fluid. When the device 20 is used to mix smaller or larger quantities of fluid of similar viscosity, the device 20 is preferably dimensionally smaller or larger.

20 While the vanes 26 used in the device 20 are preferably curved, it is possible to use vanes which are flat. The vanes 26 are preferably curved for at least one reason, in that such allows the vanes 26 to have an increased surface area without extending inwardly from the periphery towards the center of the plate 24 beyond the preferred ratio set forth above. Also, it is noted that while the vanes 26 extending from the top and bottom of the plate 24 are preferably oriented in the same direction, they may be oriented in opposite directions (i.e. the convex surfaces of the top and bottom sets of vanes 26 may face opposite directions).

25 In an alternate version of the invention, vanes only extend from one side of the plate. The vanes may extend from either the top or the bottom side. Such an arrangement is useful when mixing in shallow containers, while retaining the advantages of high fluid flow mixing rates and the straining capability.

30 It will be understood that the above described arrangements of apparatus and the method therefrom are merely illustrative of applications of the principles of this invention and many other embodiments and modifications may be made without departing from the spirit and scope of the invention as defined in the claims.



WHAT IS CLAIMED IS:

1. A method of mixing a fluid comprising the steps of:  
isolating a fluid to be mixed in a container;  
providing a mixing device, said mixing device comprising a generally circular central support plate  
5 having a top side, a bottom side and a peripheral edge and having a diameter and an axis extending through  
said plate generally perpendicular to said top and bottom sides, a shaft connected to said plate and  
extending therefrom parallel to said axis for engagement with a rotary drive, and number of narrow,  
elongate vanes extending from said first and second sides of said plate and generally parallel along said  
axis, the number of vanes extending from each side of said plate being between about 4 and 12 per inch  
10 of diameter of said plate, and wherein said vanes have a length between about .1 and 2 times the diameter  
of said plate;  
positioning said device in said container;  
engaging said shaft with a rotary drive means; and  
rotating said mixing device with said rotary drive means.
- 15 2. The method in accordance with Claim 1, wherein said fluid is a liquid.
3. The method in accordance with Claim 1, further including the steps of drawing fluid from a top  
portion of said container towards said top side of said plate and expelling said fluid from said device through said  
vanes generally radially outwardly perpendicular to said axis.
4. The method in accordance with Claim 1, further including the steps of drawing fluid from a bottom  
20 portion of said container towards said bottom side of said plate and expelling said fluid from said device through  
said vanes generally radially outwardly perpendicular to said axis.
5. The method in accordance with Claim 1, wherein said providing step further comprises positioning  
said vanes at said peripheral edge of said plate.
6. The method in accordance with Claim 1, wherein said providing step further comprises joining a  
25 hoop to the free ends of the vanes extending from each side of said plate.
7. The method in accordance with Claim 1, further including the step of removing said device from  
said container, inserting said device into a container containing a cleaning agent, and rotating said device within said  
cleaning agent to clean said device.
8. A method of mixing a fluid comprising the steps of:  
30 providing a mixing structure in a container of fluid, said structure comprising a central generally  
circular plate having a top side, a bottom side, an outer edge and an axis passing therethrough generally  
perpendicular to said side, a shaft having a first end connected to said plate and extending therefrom said  
shaft extending generally parallel to said axis, and a number of vanes spaced about the periphery of said  
plate and extending from both said top and bottom sides thereof generally parallel to said axis, said vanes  
35 generally defining an open first end and an open second end of said structure;  
positioning said structure in a container containing fluid to be mixed;

-8-

rotating said structure within said fluid in said container;

drawing fluid downwardly from a top surface of said fluid through said open first end defined by said vanes and upwardly from a bottom surface of said fluid through said open second end defined by said vanes in a direction generally parallel to said axis; and

5 expelling said fluid in a direction generally perpendicular to said axis through said vanes.

9. The method in accordance with Claim 8, wherein said providing step further comprises providing said vanes in a number between 4 and 12 per inch diameter of said plate.

10. The method in accordance with Claim 8, wherein said providing step further comprises providing said vanes in a length of .1 to 2 times the diameter of said plate.

10 11. The method in accordance with Claim 8, wherein said providing step further comprises providing said vanes on said plate such that said vanes extend inwardly from said periphery no more than about .1 to .35 of the radius of said plate.

12. A method of mixing a fluid comprising the steps of:

15 providing a mixing structure comprising a central generally circular plate having a top side, a bottom side, an outer edge and an axis passing therethrough generally perpendicular to said top and bottom sides, a shaft having a first end connected to said plate and extending therefrom generally parallel to said axis, and a number of vanes spaced about the periphery of said plate, said vanes extending inwardly of said periphery of said plate no more than .1 - .35 of the maximum radial distance from a center of said plate to a peripheral edge thereof, and extending from both said top and bottom sides thereof generally parallel to said axis;

20 positioning said mixing structure in a container containing fluid; and

rotating said structure within said container containing fluid.

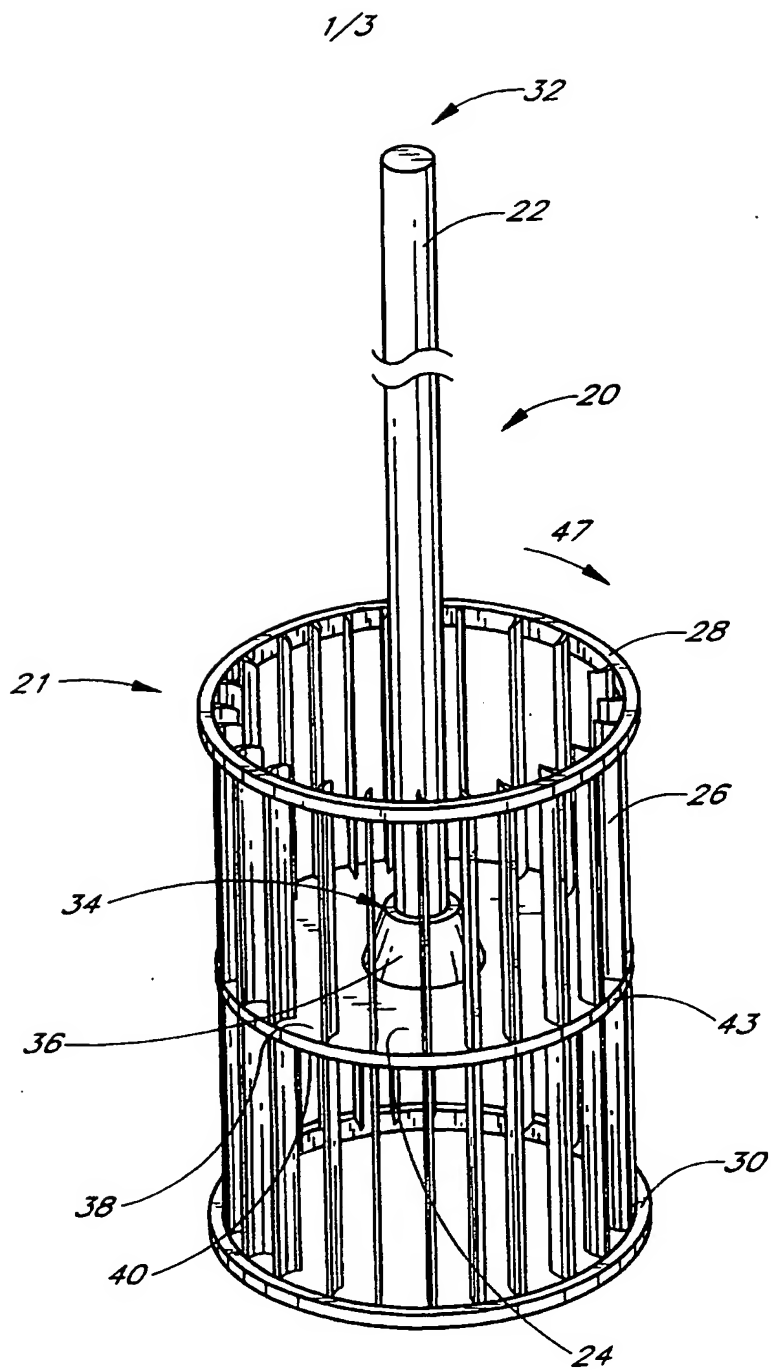
13. The method in accordance with Claim 12, wherein said providing step further comprises providing a first hoop joining the free ends of said vanes extending from said top side of said plate and a second hoop joining the free ends of said vanes extending from said bottom side of said plate.

14. A device for use in mixing a fluid comprising a drill having a motor having an output shaft driving a chuck member, and a mixing structure, said mixing structure comprising a mixing structure for use in mixing a fluid, said structure comprising a central plate having a top side and a bottom side and a peripheral edge, a number of vanes extending from at least said top side of said plate and spaced about said periphery thereof, and a shaft, said shaft having a first end connected to said plate and said second end coupled to said chuck member of said drill.

15. The device in accordance with Claim 14, wherein said vanes number between 4 and 12 times the diameter of the plate.

16. The device in accordance with Claim 14, wherein said vanes have a length between .1 and 2 times the diameter of said plate.

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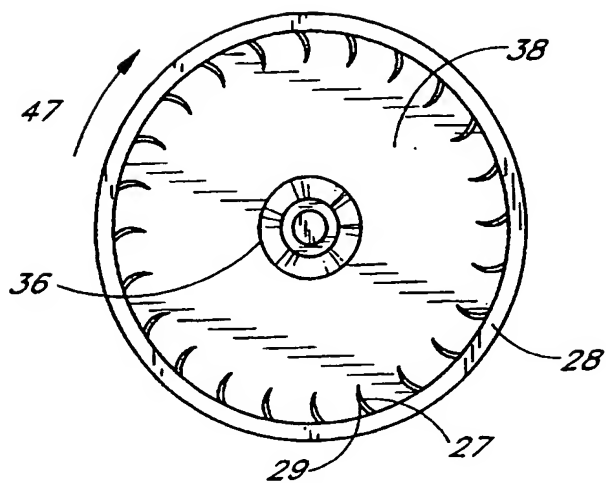


FIG. 2

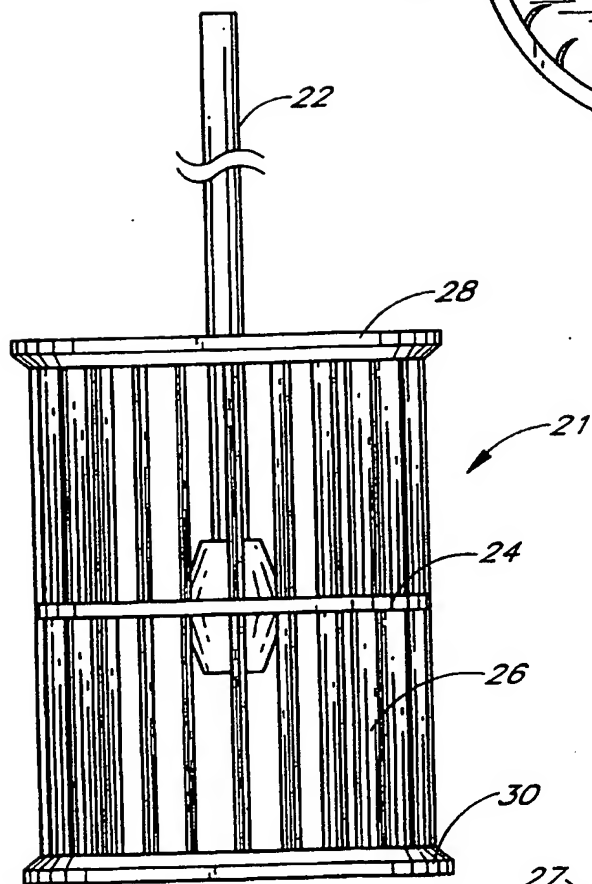


FIG. 3

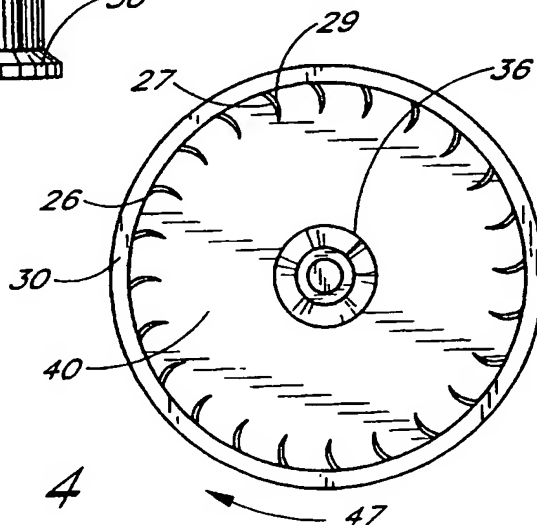
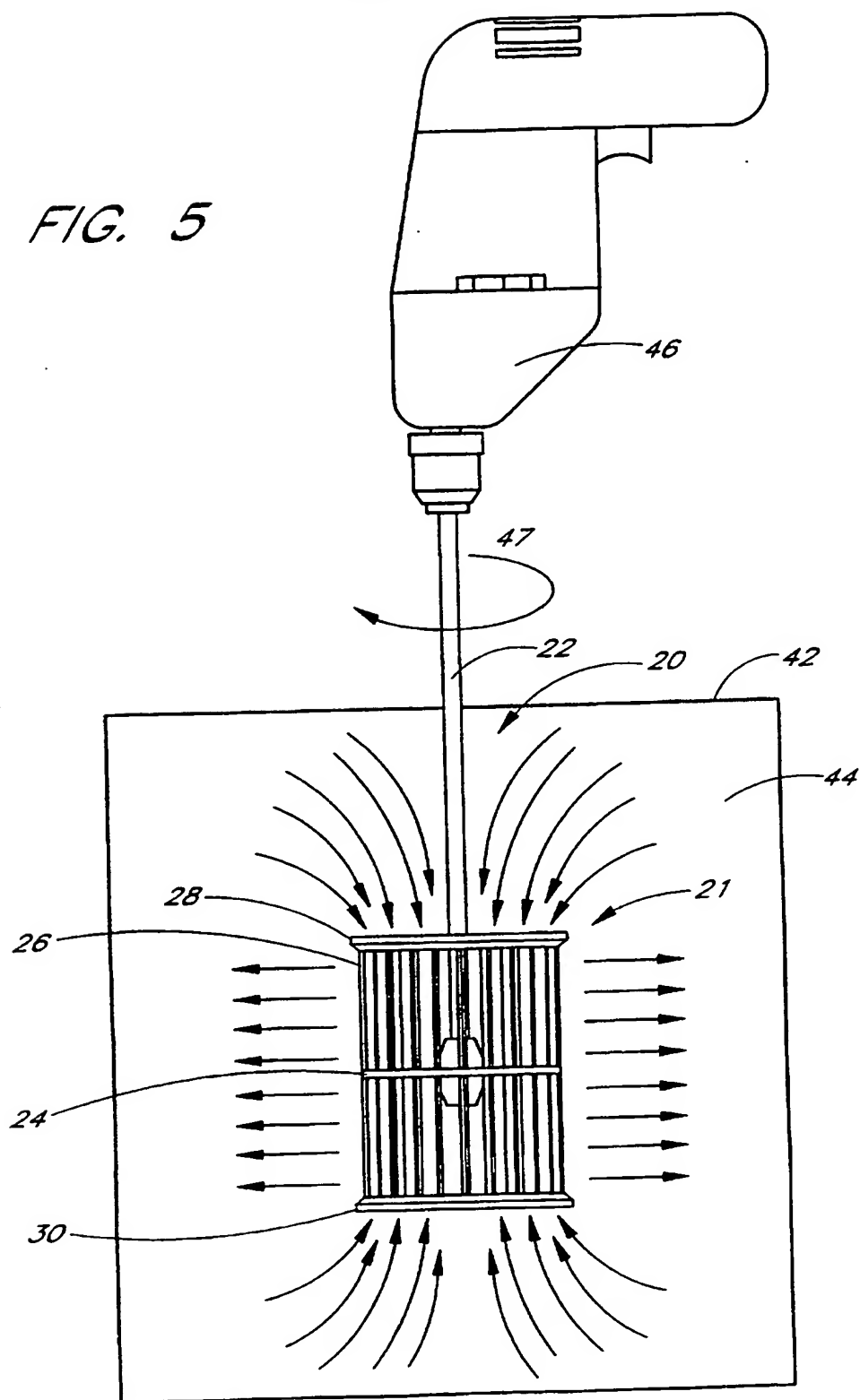


FIG. 4

3/3

FIG. 5



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/19345

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B01F 5/12, 7/26, 7/32

US CL : 366/265, 317, 605

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 134/149, 157; 366/129, 130, 262, 263, 265, 270, 317, 342, 343, 605; 416/178, 184, 187

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 3,690,621 A (TANAKA ET AL.) 12 September 1972, see Figures 1, 3, and 4 and Col. 2, lines 34-65.	1-5, 8-12 ----- 6, 7, 13-16
X — Y	US 1,084,210 A (HOWARD) 13 January 1914, see Figures 1 and 2; Page 1, lines 24-32 and lines 51-57; Page 2, lines 26-31 and lines 54-58.	1-5, 8-12 ----- 7, 14-16
X	US 4,893,941 A (WAYTE) 16 January 1990, see Figures 1, 2, and 5 and Col. 2, lines 64-68 and Col. 3, lines 1-56.	14-16
Y	US 1,765,386 A (WAIT) 24 June 1930, see Figures 3 and 4 and Page 2, lines 6-26.	6, 13
Y	US 3,733,645 A (SEILER) 22 May 1973, see Figure 6 and Col. 4, lines 16-18.	7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/19345

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,166,303 A (CHAPMAN) 19 January 1965, see Figure 2 and Col. 1, lines 8-43 and Col. 2, lines 41-49.	14-16
A	US 2,724,547 A (ABBOTT ET AL.) 22 November 1955, see Figures 1 and 2.	1, 5, 6, 12, 13
A	US 3,464,622 A (DENNIS) 02 September 1969, see Figures 1-3.	1, 5, 6, 12, 13
A	US 4,483,624 A (BACON, JR. ET AL.) 20 November 1984, see Figures 1, 3, and 4.	1, 2, 4-6, 12, 13
A	US 4,738,593 A (REIFSCHNEIDER) 19 April 1988, see Figures 1-2.	1, 5, 6, 12, 13